STUMP SPROUTING 2 YEARS AFTER THINNING IN A CHERRYBARK OAK PLANTATION

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Abstract–Stump sprouts are considered an important regeneration source in hardwood management, especially in upland oak-dominated forests. Less is known about stump sprouting in bottomland oak forests. Therefore, the objective of this study was to determine the success and growth of stump sprouts following 2 thinning levels, 70-75 percent of initial stocking (light thinning) and 45-50 percent of initial stocking (heavy thinning) in a 35-year-old cherrybark oak (*Quercus pagoda* Raf.) plantation in Concordia Parish, LA. Two growing seasons after thinning, cherrybark oak sprout success was 37 percent across the study site, a 200 percent decrease from the previous year. A severe drought occurred during this time and may have contributed to the low sprouting success. Stumps averaged 8.5 sprouts over the 2-year study period, and dominant sprouts were 82 inches tall. Results from this study indicate that greater weights should be placed on stump sprout potential in bottomland hardwood regeneration evaluation models.

INTRODUCTION

Sprouts are generally defined as shoots arising from the base of woody plants or as suckers from roots (Helms 1998). Though called various names, tree sprouts can usually be divided into 3 types for management purposes: seedling sprouts, root sprouts, and stump sprouts. Seedling sprouts are stems that arise from existing or severed seedlings or saplings (≤3 inches dbh) where the root system may be several to many years older than the stem (McQuilkin 1975). Root sprouts, or suckers, arise from adventitious suppressed buds on root systems of existing or severed trees (Kormanik and Brown 1967). Stump sprouts arise from the base of severed stems and can appear anywhere from the top to the base of the stump.

Stump and root sprouts are considered one of three broad classes of oak reproduction (Aust and others 1985), the others being new seedlings that develop from acorns which germinated just before or soon after harvest and advance regeneration – older regeneration living underneath a forest canopy (Smith and others 1997). Advance regeneration and sprouts have long been considered the most important source of hardwood regeneration, especially for the various oak species (Hodges 1987, Johnson 1994). Sprout survival and development have been well-studied for a variety of upland oak species including northern red oak (*Quercus rubra* L.) (Johnson 1975, Johnson and Rogers 1980), black oak (*Q. velutina* Lam.) (Johnson and Sander 1988), white oak (*Q. alba* L.) (McQuilkin 1975, Lynch and Bassett 1987), and others (Cobb and others 1985, Lowell and others 1987). This information has been incorporated into several hardwood regeneration evaluation models designed to determine if sufficient density and stocking of oak regeneration exists prior to a harvest for regeneration success (Sander and others 1976, Johnson 1977, Sander and others 1984, Dey 1993, Dey and others 1996).

Less is known about the role of sprouting in the regeneration of bottomland oak species (Gardiner and Helmig 1997, Golden 1999). The stump sprouting component of bottomland hardwood regeneration evaluation models rely on the best information currently available, i.e., personal observations, results from upland oak sprouting research, and limited bottomland oak sprouting research (Johnson 1980, Johnson and Deen 1993, Hart and others 1995, Belli and others 1999). Therefore, the objective of this study was to add to the sprouting knowledge of bottomland oak species. Specifically, we examined success and growth of cherrybark oak (*Q. pagoda* Raf.) stump sprouts following two intensities of thinning in a 35-year-old plantation. Two-year results are reported.

MATERIALS AND METHODS

Study Site Description

The study site is located on the Red River Wildlife Management Area in Concordia Parish, east-central LA. Physiographically, the site is located in the Natural Levee Subregion, Mississippi River Floodplain Region of the Alluvial Floodplain Province (Evans and others 1983) and is protected from flooding by the mainline levee system. Soils are composed of Commerce silt loam (Aeric Fluvaquents) and Bruin silt loam (Fluvaquentic Eutrudepts). The former soil is deep and somewhat poorly drained while the latter soil is deep and moderately well drained. Rainfall averages 59 inches per year and is generally evenly distributed throughout the year although periodic summer droughts occur (Evans and others 1983). Average temperature is 67 degrees Fahrenheit with a high of 81 degrees Fahrenheit in July and August (Evans and others 1983). Cherrybark oak site index, base age 50 years, was estimated at 110 feet (Baker and Broadfoot 1979).

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The plantation was established on a 350-acre agriculture field during 1969-1972. Planting density was variable but averaged 411 seedlings per acre. Cherrybark oak planting accounted for 43 percent of the total area and was primarily located in one portion of the field.

Treatments

Fifteen, 1.8-acre rectangular plots (396 by 198 feet) were established in the cherrybark oak portion of the plantation. Each plot consisted of a 0.4-acre interior measurement plot (264 by 66 feet) with the remaining area as buffer. Diameter of all trees ≥ 5 inches dbh was measured in each interior plot and a hand-drawn map was made for the location of each tree for future reference. These data were used to determine initial stocking using Goelz's (1995) stocking guide for southern bottomland hardwoods. Plots were then blocked, 3 plots per block, by initial stocking to reduce pre-harvest variation among treatments. Overall stocking among the plots was 89 percent, with average stocking among the plots in each block ranging from 76 percent in the lightest stocked block to 104 percent in the heaviest stocked block.

Three thinning treatments were randomly assigned to the plots in each block. These treatments included a light thinning in which stocking was reduced 70-75 percent, a heavy thinning which reduced stocking to 45-50 percent, and an unthinned control. Tree marking guidelines were developed using the stocking information along with a tree class system (species, crown class, and butt-log grade) to determine those trees that would serve as future crop trees (preferred stock), those trees which could remain until the next thinning or could be marked for the present thinning (reserve stock), and those trees that should be removed in the present thinning operation (cutting stock) (Putnam and others 1960, Meadows 1996). All cutting stock trees were marked then reserve stock trees were marked as needed until the desired residual stocking was attained. Thinning operations were conducted from 30 September 1998 through 3 February 1999 across the plantation. A total of 141 cherrybark oak trees were harvested in the treatment plots.

Measurements

Assessments were made of each cherrybark oak stump during the 1999/2000 and 2000/2001 dormant seasons, representing the 1999 and 2000 growing seasons, respectively. Observations were noted as to whether the stump sprouted, how many sprouts were present, and the height of the tallest sprout (in centimeters) for each stump when 2 or more sprouts were present. Due to the proliferation of sprouts in a small location on many stumps, only those sprouts that were ≥ 1 foot tall and located within 3 inches of the stump were counted. These criteria allowed us to distinguish sprouts from branches within a sprout and to avoid counting stems that paralleled the surface of the ground despite being as long as 3 feet. On dead sprouts, we noted if they had initiated growth prior to their death.

Analyses

Sprout success, calculated as the number of stumps with at least one living sprout divided by the total number of stumps, sprout numbers per stump, and height of the tallest sprout on each stump were analyzed using analysis-of-variance in a randomized complete block design. Initial stocking density represented the blocking factor. Since controls contained no stumps, only two treatments, light thinning and heavy thinning, were included in the analyses. Regression techniques were also used to determine if relationships existed between the variables and pre-harvest tree diameter. All analyses were done using PC-SAS (SAS 1985). An alpha level of 0.05 was used to determine significant differences. Height values were converted to English units for reporting purposes.

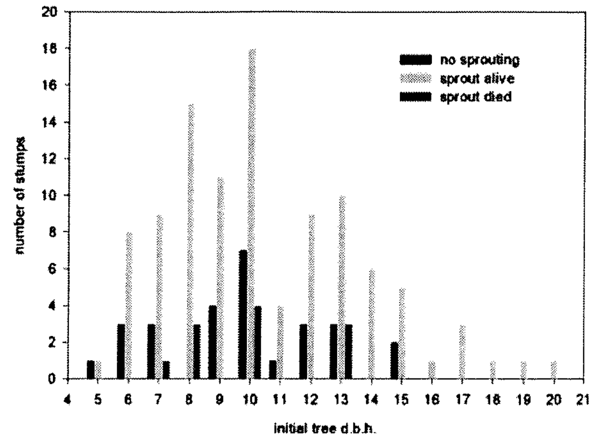

Figure 1—1999 diameter distribution of cherrybark oak sprouting success for light and heavy thinning treatments on the Red River Wildlife Management Area, Concordia Parish, LA.

RESULTS AND DISCUSSION

Sprout Success

One growing season after thinning 81 percent of the cherrybark oak stumps had sprouted. Sprouting occurred for all diameter classes with nearly 100 percent sprouting for trees ≥ 14 inches (n = 20) (figure 1). Eleven of these sprouts died during the year for a sprouting success of 73 percent (table 1). Sprout success in the light thinning treatment was greater than in the heavy thinning treatment,

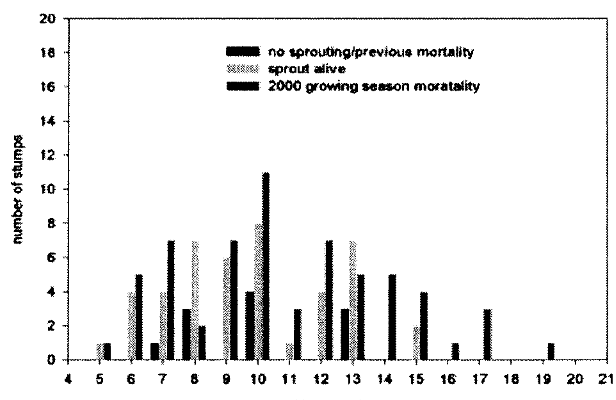

Figure 2—2000 diameter distribution of cherrybark oak sprouting success for light and heavy thinning treatments on the Red River Wildlife Management Area, Concordia Parish, LA.

Table 1–Stump sprout characteristics two years after light and heavy thinning in a cherrybark oak plantation on the Red River Wildlife Management Area

	Sprout Success (percent)				No. Sprouts per Stump				Height (cm)				Ht. Growth (cm)	
Treat- ment	1999		2000		1999		2000		1999		2000		2000	
Light	79a[1]	1.1[2]	33a	4	8	1.1	10	1.7	60	4	79	13	12	9
Heavy	66b	3.4	44b	5	9	0.8	7	0.9	60	2	86	3	28	3
p-value	.0010		.0066		.9444		.3181		.9242		.6479		.2392	

[1] Numbers followed by different letters within a column are significantly different at p 0.05.
[2] The second column within each growing season represents ±1 standard error.

79 percent to 66 percent, respectively (table 1). Greater success in the light thinning may be attributed to a greater number of trees harvested in the smaller dbh size classes, especially the 6- and 8-inch dbh classes, with subsequent greater sprouting potential (figure 1). Greater sprouting for smaller-sized trees has been reported for other oak species (Johnson 1975, Golden 1999). Sprouting success differences also existed between blocks (initial tree stocking) although no discernable patterns existed.

Sprout success dropped considerably the second year after thinning (2000 growing season). Success was only 37 percent across the study site, a 200 percent decrease from the previous growing season (figure 2). Mortality was distributed across the range of dbh but was most pronounced in the 8- and 10-inch dbh classes (figure 2). The likely cause for this increased sprout mortality was the severe drought that occurred during the two-year study period. Rainfall totals at the Marksville, LA station (about 15 miles southwest of the Red River WMA) were 75 percent and 72 percent of normal for 1999 and 2000, respectively. Twenty-four sprouts (17 percent of the total number of stumps) perished during the second growing season. Many of these sprouts grew well during the early growing season with multiple flushes, flush lengths ≥ 1 foot, and leaves distributed along the stem of each flush—all signs of good sprout vigor. Unlike the previous growing season, success was greater in the heavy thinned plots compared to the light thinned plots, 42 percent to 32 percent, respectively (table 1). With a greater number of trees thinned, the heavy thinned plots may have had less below-ground competition with a subsequent greater amount of soil moisture available for the stump sprouts. Differences continued to exist in sprout success between blocks but, as with the 1999 growing season, no discernable patterns existed.

Gardiner and Helmig (1997) reported 100 percent survival of stump sprouts 1 year following light and heavy thinning in a 28-year-old water oak (*Q. nigra* L.) plantation. Survival decreased considerable by year 2 and followed a gradual decline through year 7. No differences in survival occurred between the thinning treatments until year 7 when survival in the heavy thinning was 23 percent greater than in the light thinning. Gardiner and Helmig (1997) attributed this difference to early crown closure and subsequent decreased light levels in the lightly thinned plots. Similar results, despite the heavy influence of the recent drought, are expected with cherrybark oak in the present study as the overstory canopy should close earlier in the light thinned plots. Golden (1999) reported only 13 percent of cherrybark oak trees had sprouts 3 years following clear felling in 0.8-acre openings. He attributed this low sprouting success primarily to the initial large tree sizes and subsequent large stump sizes. Sprouting success has been shown to decrease with increasing parent tree diameter (Johnson 1975), possibly due to the inability of suppressed buds to break through the thicker bark associated with larger trees or the inability of sprouts to produce enough food to keep the large root system alive.

Sprout Number

Sprout numbers per stump varied little between treatments and growing seasons (table 1). Sprout numbers averaged 8.5 across both years. Self-thinning within sprout clumps has yet to occur. Apparently, the aforementioned drought has had little effect on survival within sprout clumps compared to sprouting success.

Gardiner and Helmig (1997) noted that 1-year-old water oak sprout clumps averaged 15 stems per stump. They also noted that thinning level did not affect the initial stem number per sprout clump. Their results showed considerable within-stump sprout mortality through the first 4 years before stabilizing at about 4 stems per sprout clump by age 7. A decrease in the stem number per sprout clump was not found with cherrybark oak during the 2 growing seasons. Longer term results are needed from the present study with cherrybark oak before more direct comparisons can be made with the sprout number per stump with water oak.

Height

Height of the tallest sprout within each sprout clump averaged 60 inches one year after thinning. Heights generally increased with increasing tree dbh ($r^2 = 0.68$ for simple linear regression), ranging from 48 inches for the 6-inch dbh class to 107 inches for the 20-inch dbh class (figure 3). Mean height increased to 82 inches following the 2000 growing season, although this represented a 27 percent decrease in height growth from the previous year. The trend of increasing heights with increasing dbh class

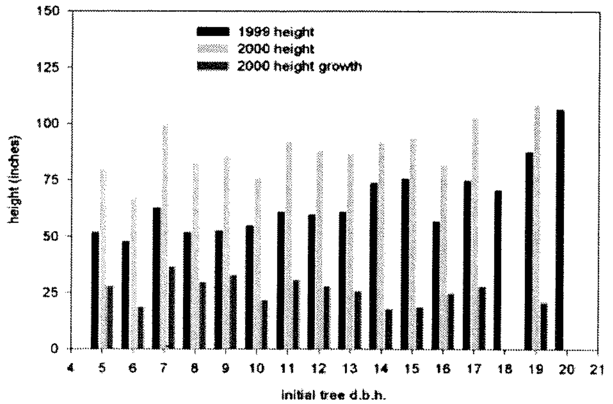

Figure 3—Distribution of 1999 and 2000 cherrybark oak sprout heights and 2000 cherrybark oak sprout height growth by dbh class on the Red River Wildlife Management Area, Concordia Parish, LA.

remained evident, though not as strong, in the second growing season (r^2 = 0.42, figure 3). Thinning regime did not influence sprout height during either growing season (table 1).

A pattern of decreasing height growth with increasing sprout age has been noted by others (Cobb and others 1985, Gardiner and Helmig 1997). Cobb and others (1985) found annual reductions in height growth of scarlet oak (*Q. coccinea* Muenchh.) sprouts ranged from 7-33 percent during the first 5 years of development following clearcutting in the upper Piedmont of South Carolina. Gardiner and Helmig (1997) also found sprout height growth decreased following thinning in a water oak plantation, from 20 inches annual growth for the first 5 years to 11 inches annual growth the next 2 years. Apparently, the rapid early height growth experience by sprouts decreases over time as the above-ground and below-ground portions of each sprout comes into balance.

CONCLUSIONS

Information on oak sprout development following partial cutting in southern bottomland forests is limited. Findings from this study with cherrybark oak in a thinned plantation are generally in agreement with Gardiner and Helmig's (1997) study of water oak sprout development in a thinned water oak plantation. Stump sprout success and growth are dependent on available resources. As these resources, especially light, diminish, slower growth and increased mortality should be expected. Therefore, future thinnings will be necessary to prolong the success and growth of these sprouts. Gardiner and Helmig (1997) mentioned thinning within sprout clumps could possibly extend sprout survival and growth, based on work conducted with upland oak species (Johnson and Rogers 1984, Lowell and others 1987). Such treatments require additional research with bottomland hardwood species.

Hart and others (1995) recent modification of Johnson's (1980) bottomland hardwood regeneration evaluation model gives 3 points for trees 2-5 inches dbh, 2 points for trees 6-10 inches dbh, 1 point for trees 11-15 inches dbh, and no points to trees ≥ 16 inches dbh. A minimum of 12 points is needed for a 0.01-acre regeneration plot to be considered adequately stocked with regeneration or regeneration potential from stump sprouts. It would take 4 trees in the smallest dbh class or 12 trees in the 11-15 inch dbh class for a plot to be considered stocked, assuming no other trees were present in the plot. Data used in the modification of Johnson's (1980) model involved primarily seedlings and saplings; limited data existed for trees ≥ 4 inches dbh to adequately evaluate the role of stump sprouts in regenerating bottomland hardwood stands (Hart and others 1995, Belli and others 1999). Results from this study indicate that more weight should be given to trees in larger size classes, especially if drought induced mortality is removed. However, the present study was limited to only 141 harvested cherrybark oak trees growing on an excellent site which was subjected to unusual weather conditions over the past 2 years. Furthermore, the current bottomland hardwood regeneration model was developed for use in stands that will receive a regeneration harvest; the subsequent regeneration will respond to open conditions. The present study involved trees that were harvested as part of a thinning operation in which an overstory canopy still exists. Shading from this overstory will influence future development of oak sprouts. Also, sprouts in the present study arose from trees that were judged to be inferior to the residual trees; therefore, sprout development from these trees may differ from sprouts which develop from the residual crop trees. Much work remains on the role of stump sprouts in regenerating bottomland hardwood stands; this includes both oak and non-oak species.

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